

Propagation of epileptic spikes revealed by diffusion-based constrained MEG source reconstruction

AC Philippe⁽¹⁾, T Papadopoulo⁽¹⁾, C. Bénar⁽²⁾, JM. Badier⁽²⁾, M Clerc⁽¹⁾, R Deriche⁽¹⁾

(1) Athena Project-Team, INRIA, Sophia Antipolis - Méditerranée, France

(2) INSERM, UMR 751, Marseille, France

anne-charlotte.philippe@inria.fr

Goal: Study of the propagation of an epileptic spike.

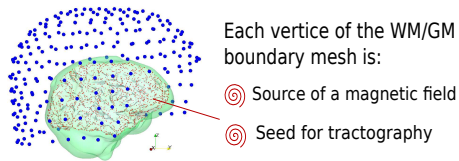
Method: 1- cortex parcellation via structural information coming from diffusion MRI (dMRI)

2- MEG inverse problem on a parcellated source space

3- study of the propagation of an epileptic spike via the active parcels

Results on real data allowing to study the spatial propagation of an epileptic spike.

- 1- Co-registration of the T1wMRI and dMRI
[soft FSL]
- 2- Surface meshes extraction
[soft Freesurfer]
- 3- Computation of the leadfield matrix G
[soft OpenMEEG]



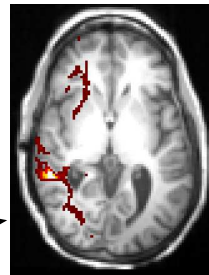
Each vertice of the WM/GM boundary mesh is:
 ⊙ Source of a magnetic field
 ⊙ Seed for tractography

Connectivity profile of a source CP:

CP(i) = connectivity value between the source and the ith voxel.

- 4- For each source:
Computation of its connectivity image.

Tool: Probtrackx
[soft FSL]

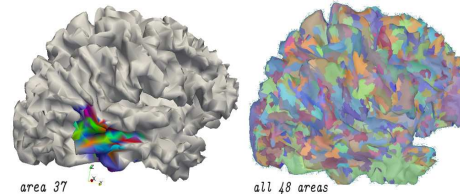


5- Pre-clustering via Brodmann's atlas

For each Brodmann area, clustering of sources having a close connectivity to all sources:

5.1- Computation of the CP-based correlation matrix R [5]

5.2- K-means algorithm on R



We reduce the initial distributed source space S into s in accordance with the cortex parcellation:

$$S = P \times s \text{ with } P(i, j) = \begin{cases} 1, & \text{if source } i \text{ is in area } j \\ 0, & \text{if not} \end{cases}$$

and compute the reduced leadfield G_p for the parcellated source space s: $G_p = G \times P$

Thus, the MEG inverse problem on the parcellated source space using Tikhonov regularization becomes :

$$\min_s \| M - G_p s \|^2 + \lambda \| s \|^2$$

where M contains the MEG measurements.

At each time sample, we want to determine the cortical areas at the origin of the activity. We call \mathcal{S}_t the set of these areas, for a time sample t

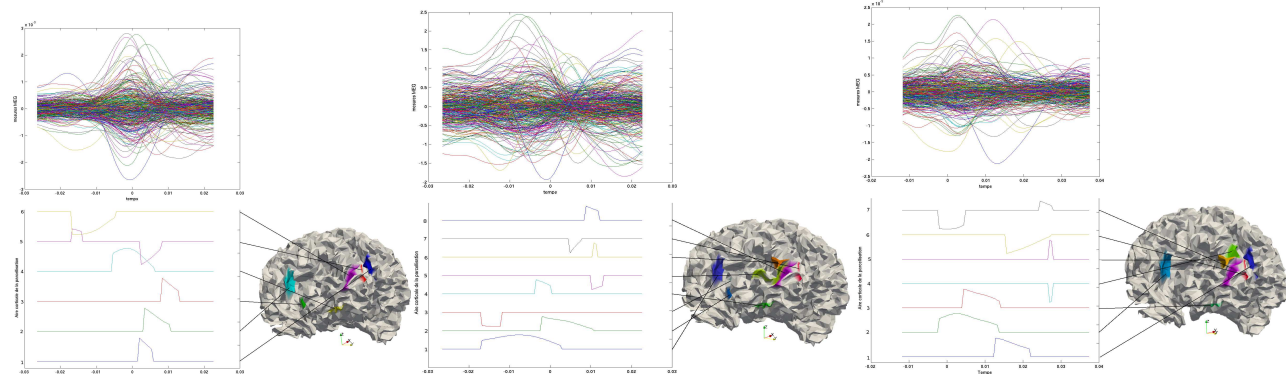
For each time sample t, we compute the power $\mathcal{P}_{p,t}$ of each area p on a sliding time window $[t - \alpha, t + \alpha]$:

$$\mathcal{P}_{p,t} = \sum_{i=t-\alpha}^{t+\alpha} |s(p,i)|^2$$

$$\mathcal{S}_t = \{p_a : \mathcal{P}_{p_a,t} > F * \max(\mathcal{P}_{p,t}), \forall p\}$$

with F a percentage.

Results on 3 epileptic spikes of a single subject.



Almost the same parcels are activated for all epileptic spikes.

The direction of propagation changes: from the back of the frontal lobe to the front or opposite direction.

The time of activation of each parcel characterizes the spike.

The parcellation allows an easier representation of source space.

The method reveals differences between spikes (direction of propagation and time of activation of parcels).

Future works will be to analyse the structural network supporting the propagation.

[1] D.S Tuch et al, Diffusion MRI of Complex Neural Architecture, Neuron, 2013.

[2] O. Sporns et al, Organization, development and function of complex brain networks, Trends of cognitive sciences, 2004.

[3] C. Baumgardner et al, Propagation of interictal epileptic activity in temporal lobe epilepsy, Neurology, 1995.

[4] AC. Philippe et al, Cortex parcellation via diffusion data as prior knowledge for the MEG inverse problem, ISBI, 2013.

[5] A. Anwander et al, Connectivity-based parcellation of broca's area, Cerebral Cortex, 2007.